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METHOD FOR STRAIGHTENING HOT PROFILED SECTIONS

[0001] The invention relates to a method for straightening profiled sections, which include a web and at least one flange, in particular double-T or U beams, with the aid of straightening tools.

[0002] After it has been hot-rolled, profiled-section steel is frequently subject to deformation and/or distortion as it cools. To eliminate resultant deviations from the desired profiled-section shape and to impart the desired straightness to the beam, the profiled sections are straightened after they have been hot-rolled and cooled. Since the deformations occur during cooling, it has not hitherto been satisfactorily possible to straighten the profiled sections while they are still hot. Although it is possible to achieve results which satisfy the appropriate standards during the operation of straightening the hot profiled sections, after final cooling the profiled sections partially spring back into a curved form which does not comply with the standards.

[0003] Therefore, in the prior art it is a requirement for the profiled section to be cooled to low temperatures (cf. for example DE 24 56 782 and US 5,060,498). For this purpose, the profiled sections are cooled in cooling beds or cooling pits. This disadvantageously gives rise to time delays, which in some cases lead to temporary production shutdowns.

[0004] If in the prior art profiled sections are straightened at higher temperatures, the profiled section is differentially cooled or heated in order to generate compressive stresses in the web (cf. DE 35 01 522 C1; DE 36 38 816 C1). After the straightening operation, the temperature of the web moves closer to that of the flanges, the intention being to reduce longitudinal tensile stresses. However, these methods are time-consuming and energy-consuming on account of the need to generate accurate temperature gradients in

the profiled sections. Furthermore, deformation of the profiled section can occur as a result of shrinkage of the web during final cooling, and this once again means that the rails which have been cooled to room temperature do not satisfy the requirements of the relevant standards. Consequently, these methods are likewise unsatisfactory.

[0005] The invention is based on the object of providing an improved method which makes it possible to straighten profiled sections in the hot state.

[0006] This object is achieved by the subject matter of the main claims. Advantageous embodiments are given in the subclaims.

[0007] The straightening method according to the invention is based on the fundamental concept of straightening the profiled sections at profiled-section temperatures of >70°C, specifically in such a manner that the straightening force is introduced directly into the flange of the profiled section. This avoids internal stresses in the profiled section, which otherwise cause deformation to the profiled section as it cools.

[0008] The straightening force is preferentially introduced into the narrow side of the flange, i.e. in the case of a profiled section with vertically oriented flange, from above or below. According to the invention, however, a straightening force does not have to be introduced in just one direction and at just one location. Within the scope of the invention, straightening forces can be introduced, for example by means of comb-like rollers, both into the lateral "main face" of the flange and the narrow side of the flange, and can also be introduced only into the lateral "main face".

[0009] The invention is based on the discovery that the change in shape of hot-straightened profiled sections which is observed in the prior art after cooling

has its origin in the differential heat quantity contents of the still-hot profiled section. In the transition region from web to flange (web root), there is a high mass concentration with a low surface area, which cools more slowly than the adjoining masses. Consequently, this area is at a higher temperature than the remainder of the profiled section. Deforming actions during the further cooling process alter the temperature and may generate temperature-dependent stress distributions. During conventional straightening, in which the straightening disks cover the web in the region of the web roots, the straightening disks impose the alternating bending operations predetermined by the approach of the straightening disks on the web, and the reciprocating movements from these bending operations are transmitted to the flange and ultimately generate the desired straight profiled section with the reduced approach settings.

[0010] During hot-straightening, the higher temperature of the web root region means a specific flow stress for the material, which is taken into account by a modified approach for the hot-straightening operation (using the conventional straightening technique). The conventional straightening generates internal stress distributions which differ from those of the starting state in the profiled sections. Internal stress peaks occur particularly in the web root region at levels which can lie in the region of the flow stress or above.

[0011] If the conventional straightening methods are used to straighten profiled sections in the hot state, internal stresses are always generated to a certain extent. The subsequent cooling alters the stress distribution and the stress levels, which leads to the distortion of the straightened profiled section which is known and observed in the prior art.

[0012] To produce straight profiled sections at higher temperatures and to retain this straight profiled section even after cooling, according to the teaching of the invention, during the straightening operation, the introduction of the

straightening force into the flange does not generate any internal stresses which adversely affect the product properties and the straightness of the profiled sections in the transition region between web and flange and in the web itself. Rather, the introduction of force into the flange retains the unproblematic stress state in the web and in the web roots, and the internal stress state in the flange is only altered to an insignificant extent. Therefore, there is no likelihood of a disadvantageous, cooling-related change in the stress state in the cooled profiled section.

[0013] The process according to the invention advantageously makes it possible for the profiled sections to be processed further while they are still in the hot state following the hot-rolling process. This leads to considerable time savings and avoids production shutdowns. Furthermore, it is possible to process the still-hot steel with less force, which means that it is in this way possible to save energy.

[0014] The method according to the invention is used to straighten profiled sections with a web and at least one flange. Profiled sections of this type include in particular T-beams, double-T-beams, U-sections and L-shaped profiled-section limbs, with the flange of all these types of profiled sections preferably being at an angle of 90° to the web, although other alignments are also readily possible.

[0015] The profiled sections are straightened at profiled-section temperatures of over 70°C, particularly preferably at temperatures of over 100°C. However, the method according to the invention also allows straightening to be carried out at higher temperatures, such as for example even approx. 200°C and above. There are various possible ways of determining and defining the profiled-section temperature. Therefore, this term is to be understood in a broad sense. The term profiled-section temperature may, for example, include the web root surface temperature and the temperature within the web root. Furthermore, it may also encompass the surface temperature of the web and of the beam edges and/or the temperature within these profiled-section elements. Furthermore, the

profiled-section temperature may also be defined by incorporating the temperature of a number of these profiled-section elements. For example, the profiled-section temperature can be defined by measuring the temperature profile throughout the entire profiled section or by measuring the temperature in some of the profiled-section elements. A method which is frequently used to define the profiled-section temperature is, for example, temperature scanning. In this case, a movably arranged temperature-measuring appliance is used to record the temperature over the beam edge, the web root, the web and then the other web root and other beam edge. The measured temperature profile is used to determine the profiled-section temperature; it is possible to give a greater weighting to the temperatures within the web roots. Therefore, according to the invention the result of a temperature scan of this type can also be understood as representing the profiled-section temperature.

[0016] According to an advantageous refinement of the method according to the invention, the straightening forces are introduced into the flange via a lateral surface of the straightening tool which is at an angle with respect to the surface of the flange on which this straightening tool acts. An apparatus of this type is described, for example, in DE 195 25 513 A1, the entire content of disclosure of which in respect of the description of an apparatus on which the method according to the invention, for example, can be carried out and in respect of the description of the way in which straightening forces can be introduced into the flange is hereby incorporated in the present application.

[0017] By way of example, the straightening tools, in particular straightening disks, are at least partially frustoconical in form and transmit the straightening force onto the flange by way of their conical lateral surface. The straightening tools may be arranged above and/or below the material to be straightened.

[0018] The angle of inclination of the active lateral surface is preferably of the order of magnitude of the angle of friction between the lateral surface and the surface on which the straightening tool acts; it is then derived from the following equation:

μ_R-disk/profiled section = tan ρ

and ensures that the flange edge compression is minimized. If the angle of friction of the lateral wings is correctly dimensioned, transverse stresses are generated in the flange, counteracting the frictional shear stress acting in the contact surface and thereby preventing flange edge compression. The angle of inclination is preferably 5°.

[0019] It is preferable for the intersection point of the surface lines of the straightening disk remote from the drive to be remote from the drive and the intersection point of the straightening disk close to the drive to be close to the drive.

[0020] To avoid bending of the flange in the horizontal, with respect to the straightening position, as a function of the straightening force, the straightening disks preferably have flange-supporting surfaces which are located on the web side of the flange and/or on the side of the flange which is remote from the web. Accordingly, the straightening tools designed as straightening disks preferably have a U-shaped or T-shaped axial cross section. The flange-supporting surfaces in each case engage alternately on the outside and inside of the flange.

[0021] To enable flange or limb sections of different dimensions to be straightened simultaneously using a pair of straightening rolls without the need to change the straightening disks, it is appropriate to use straightening disks with a comb-like axial cross section.

[0022] In this case, a straightening disk of this type comprises, preferably in a single piece, individual disks between which the active lateral surfaces which are inclined with respect to the horizontal according to the invention are located and the lateral surfaces of which support the flange or web on one or both sides of the straightening position.

[0023] Not all the straightening tools need to be provided with the active lateral surface. For example, it is possible for only straightening tools which are on the inlet side to be arranged with an active lateral surface running at an angle with respect to the straightening axis. In extreme circumstances, it is in each case sufficient for one suitably configured straightening tool or tool pair to be arranged in proximity above and below the material to be straightened. It is also possible for straightening tools configured in this manner to be arranged below the material to be straightened only in the outlet region.

[0024] The lateral or oblique surfaces which are used in the method according to the invention allow an extremely high level of straightening accuracy when straightening the hot profiled sections. In particular, they avoid the occurrence of flange compressions and outwardly directed bulges in the region of the flange edges and protect the favorable internal stress state of the unstraightened profiled section which originates from the hot-rolling of the profiled sections.

[0025] The invention is explained in more detail below with reference to figures, in which:

[0026] FIG. 1 diagrammatically depicts a straightening apparatus which is preferably used in the method according to the invention, with an upper straightening disk pair, partially in axial longitudinal section,

[0027] FIG. 2 shows an enlarged illustration of part of the two straightening disks,

[0028] FIG. 3 shows a straightening apparatus with outer flange guidance,

[0029] FIG. 4 shows an enlarged illustration of part of the two straightening disks,

[0030] FIG. 5 shows an axial longitudinal section through a straightening roller for flange-supported straightening with different beam dimensions,

[0031] FIG. 6 shows part of the straightening roller from Fig. 5,

[0032] FIG. 7 shows a straightening sleeve with a cylindrical middle part in an axial longitudinal section,

[0033] FIG. 8 shows part of the straightening sleeve from Fig. 7 on a larger scale and,

[0034] FIG. 9 shows a cylindrical straightening sleeve.

[0035] The straightening apparatus comprises a drive 1, the individual parts of which are not illustrated in more detail and to which there is connected a shaft 2, on which two straightening disks 3, 4 are arranged above a double-T beam 5. The latter has a web 5a and two flanges 5b and 5c. In the axial direction, the straightening disks 3, 4 have a T-shaped cross section and comprise a part 6 which is in the form of a circular disk, in each case acts on the inner side of the two flanges but does not touch the web of the flange and merges into a

frustoconical shoulder 7. The small-diameter surfaces 8 of the frustoconical shoulders 7 are in each case directed outward and their lateral surfaces are in nonpositive engagement with the flange edges. The lateral surface or surface line 9 runs at an angle ρ with respect to the surface of the narrow side of the flange or to the horizontal or the spacer sleeves 10. The spacer sleeves 10 are used to set the distance between the straightening disks and the profiled-section height (flange spacing) of the beam that is to be straightened. Accordingly, the included angle ρ results between the surface line 9 and the narrow side face of the flanges. The height Z of the frustoconical shoulders is such that the narrow sides of the flanges are supported over their entire height.

[0036] The straightening disks 11, 12 shown in Figs. 3 and 4 are fundamentally arranged and constructed in the same way as in Fig. 1, 2; however, they support the flanges on the outer side and have conical shoulder surfaces 7, the large-diameter surfaces 13 of which face inward or toward one another. In this way, in each case the same included angle between the lateral surfaces or surface lines 9 and the horizontal or narrow sides of the beam flanges results as in the case of the straightening disks 3, 4 shown in Fig. 1, 2.

[0037] The straightening rollers 15, 16 shown in Fig. 5, 6 comprise a plurality of flange-supporting individual disks 17, 18, 19, 20 which are preferably integrally connected to one another and between each of which there is a frustoconical transition 21, 22, 23. In this way, grooves 24, 25, 26 for receiving the flanges of beams of different dimensions are produced between the disks 16 to 20. The surface lines of the frustonical transitions 21, 22, 23 in turn produce, together with the opposite narrow sides of the flanges, the included angle ρ according to the invention which has already been explained above.

[0038] The straightening apparatus which is suitable for carrying out the method for hot-straightening in accordance with the invention need not be

equipped entirely with the angled straightening tools (straightening disks or straightening sleeves); rather, it is sufficient for these tools to be arranged in the region of the largest bending amplitudes, i.e. on the inlet side, which without the straightening tool according to the invention would also lead to the greatest compressions or deviations. On the other hand, it is also possible for all the upper straightening tools to be designed as disks or multi-disk rollers if, when straightening with a large pitch (distance between two adjacent straightening axes) and accordingly low straightening forces, cylindrical straightening sleeves 28 which extend from flange to flange may be arranged beneath the material to be straightened.

[0039] Figs. 7 to 9 illustrate further variants of apparatuses which can be used with the method according to the invention. Identical elements are in each case denoted by the same reference designations.

[0040] The apparatuses illustrated allow the direct introduction of force into the flange of a profiled section, with the result that it is also possible to straighten hot profiled sections at a temperature of over 70°.